IN THE UNITED STATES DISTRICT COURT
FOR THE SOUTHERN DISTRICT OF TEXAS
CORPUS CHRISTI DIVISION

JOSE HERNANDEZ, AS NEXT FRIEND OF AN INCAPACITATED ADULT, IRMA HERNANDEZ,	)	
Plaintiff,	)	
vs.	)	**CIVIL ACTION NO. C-04-319**
FORD MOTOR COMPANY	)	
Defendant.	)	

DEFENDANT FORD'S *DAUBERT* MOTION TO EXCLUDE THE TESTIMONY OF PLAINTIFF'S EXPERT DAVID RENFROE REGARDING FORD'S INTERNAL STANDARD FOR ROLLOVER RESISTANCE OF A VEHICLE

Defendant Ford Motor Company ("Ford") submits this *Daubert* motion to exclude a limited portion of the proposed testimony of David Renfroe, an expert retained by Plaintiff to testify regarding the rollover stability of the 1996 Explorer at issue in this case. The only portion of Dr. Renfroe's testimony that Ford seeks to exclude on *Daubert* grounds is his opinion regarding Ford's internal standard for rollover resistance of a vehicle. Dr. Renfroe's proposed testimony on this issue violates Fed. R. Evid. 702 because (1) he has no expertise about Ford, its employees, or the processes by which Ford communicates information or makes decisions, that would qualify him to express an expert opinion on this subject; (2) a determination of Ford's knowledge or intent does not require specialized knowledge or expertise, and thus the jury can make such a determination on its own, without expert assistance; and (3) testimony by Dr. Renfroe on this subject, based on the documents he cited, is speculative and conjectural and thus will not assist the trier of fact.

In addition, testimony by Dr. Renfroe based on or about such documents should be excluded under Rule 403 of the Federal Rules of Evidence, because the probative value, if any, of such testimony is substantially outweighed by the danger of unfair prejudice, confusion of the issues, misleading the jury, and by considerations of undue delay.

LEGAL ARGUMENT

I. THE SPECIFIC OPINIONS THAT FORD SEEKS TO EXCLUDE.

Dr. Renfroe's basic opinion is that the subject 1996 Ford Explorer is defective because it has inadequate stability or resistance to rollover. Put simply, his criterion for rollover stability defect is whether or not the vehicle can be made to "tip up" by steering inputs alone on flat, dry pavement. Dr. Renfroe opines that various instrumented vehicle tests of comparable Explorers demonstrate that it fails to meet this criterion. This is a design defect opinion, as repeatedly expressed in the conclusion of Dr. Renfroe's report. [Report of D. Renfroe, *attached as* Exhibit A, at 16.]

While Ford and its rebuttal expert witness regarding vehicle handling and stability, Donald Tandy, disagree with Dr. Renfroe's defect criterion, Ford does not assert a *Daubert* challenge to his basic rollover stability opinion. The testimony that Ford challenges is Dr. Renfroe's assertion that Ford *shares* his defect criterion. This is untrue, and Dr. Renfroe's opinion in this regard is inadmissible under *Daubert* and Fed. R. Evid. 403.

Ford seeks exclusion of the opinions expressed in the following portions of Dr. Renfroe's report:

- The first paragraph of the section titled "What is Ford's Internal Standard for Rollover Resistance of a Vehicle," on page 4 of Dr. Renfroe's report, which reads as follows:

> In a Ford document dated November 18, 1986, titled *Light Truck Limit Handling Objectives*, Paul Hackett and K. P. Snodgrass stated, "...Trucks must still be designed to be safe and predictable in even the

most severe accident avoidance situations. Light Truck Engineering's goal is to design a truck that will provide safe and predictable response in **limit handling situations**" (emphasis added) [108]. Hackett and Snodgrass further promoted this idea in a presentation, "The objective of this half of the presentation is to describe six important vehicle parameters that influence vehicle limit handling characteristics and their relationship to steering and suspension parameters. Limit handling refers to the behavior of a vehicle at the maximum lateral acceleration the vehicle is capable of reaching. A vehicle should be controllable, predictable and stable up to and including the limit of lateral acceleration" [56]. In a 1973 letter that Ford sent to the National Highway Traffic and Safety Administration, Ford stated on page 3, "Passenger cars must be forgiving of all manner of 'unskilled' driver situations that precipitate wild, panic-motivated, evasive maneuvers of drivers of widely-varying abilities. Ford passenger cars are designed to forgive or, in the extreme, to 'slide-out' rather than roll over" [109]. Again, the philosophy was restated with regard to the Bronco II in reference 127 page 2 wherein the authors in justifying the over-involvement of Jeep CJ's in rollover accidents state that the Bronco II [sic] the design process "Optimized vehicle handling parameters which virtually **preclude** vehicle over-reaction to excessive steering wheel inputs in accident avoidance maneuvers." On page 2 this was further expanded by saying, "the Bronco II is projected to **remain stable** for all speeds at the **maximum steering wheel input demand** as determined from human factors analysis." This design attitude was confirmed by Helen Petrauskas, Ford's VP of Environment and Safety Engineering, in her testimony before the Committee on Commerce, U.S. House of Representatives in September, 2000, when she referred to the previously cited guideline and said, "The objective of this guideline is to design and develop a vehicle that will remain stable under all operating conditions, including accident avoidance maneuvers. The guideline states that the vehicle should respond in a predictable manner and give the driver perceptible signals that the vehicle is at its limit" [110]. This is historically consistent with Ford's design philosophy dating from 1971, where C. R. Ennos, Manager of Body Research and Engineering at Ford, stated, "Primarily, the vehicle's handling characteristics should prevent rollover occurring unless excessively severe conditions are encountered. Our test technique should demonstrate, therefore, that vehicle's handling characteristics are anti-rollover" [32]. Thus this anti-rollover design philosophy has existed at Ford over the entire duration of the design and construction of the Ford Explorer from 1971 till September of 2000.

Ex. A, at 4.

- The first full paragraph on page 5 of Dr. Renfroe's report, also a part of the section titled "What is Ford's Internal Standard for Rollover Resistance of a Vehicle," reads as follows:

"Ford Motor Co. not only knew that the Ford Explorer was being *used* as a passenger car, but they also *marketed* the vehicle to be used as a passenger vehicle. The bottom line appears to be a consensus,

> especially at Ford, that the vehicle should not rollover on a flat and level surface from steering inputs alone."

Id., at 5.

- The concluding two sentences of the top paragraph on page 6 of Dr. Renfroe's report, a continuation of the last paragraph on page 5, which is also a part of the section titled "What is Ford's Internal Standard for Rollover Resistance of a Vehicle," read as follows:

> "Obviously, it is the objective of Ford and other manufacturers from their own statements to design the vehicle such that all customers will be safe if they try to maneuver around a bouncing ball followed by a child [9]. They intended to do this by designing the vehicle such that it would not roll over on a flat surface with steering input only as evidenced by the testing that was conducted by Ford [9]."

Id., at 6.

- The first sentence of the section titled "Does the Explorer pass Ford's internal standard?" on page 7 of Dr. Renfroe's report," reads as follows:

> "First, we have discussed that Ford's design philosophy since 1971 has been to design vehicle's [sic] that do not roll over on a flat surface from steering inputs alone."

Id., at 7.

II. DR. RENFROE'S OPINIONS ABOUT FORD'S INTERNAL STANDARD FOR ROLLOVER RESISTANCE IS INADMISSIBLE UNDER RULE 702 OF THE FEDERAL RULES OF EVIDENCE.

Rule 702 of the Federal Rules of Evidence states:

> If scientific, technical, or other specialized knowledge will assist the trier of fact to understand the evidence or to determine a fact in issue, a witness qualified as an expert by knowledge, skill, experience, training, or education, may testify thereto in the form of an opinion or otherwise if (1) the testimony is based upon sufficient facts or data, (2) the testimony is the product of reliable principles and methods, and (3) the witness has applied the principles and methods reliably to the facts of the case.

For expert testimony to be admissible, it must meet two requirements: the witness giving the testimony must be qualified as an expert on the subject about which he intends

to testify; and testimony must assist the trier of fact in understanding the evidence or determining a fact in issue.

As the proponent of Dr. Renfroe's testimony, the Plaintiff bears the burden of proving its admissibility under *Daubert* and Rule 702. *Mathis v. Exxon Corp.*, 302 F.3d 448, 459-60 (5th Cir. 2002).

A. **Dr. Renfroe Is Not Qualified to Give An Opinion on Ford's Internal Standard for Rollover Resistance.**

In order for Dr. Renfroe to express opinions about Ford's internal standard for rollover resistance, he must possess special "knowledge, skill, experience, training, or education" so that they can "actually assist the jury in arriving at an intelligent and sound verdict." *Viterbo v. Dow Chem. Co.*, 826 F.2d 420, 422 (5th Cir. 1987). "Stated more directly, the trial judge ought to insist that a proffered expert bring to the jury more than the lawyers can offer in argument." *Salas v. Carpenter*, 980 F.2d 299, 305 (5th Cir. 1992) [quoting *In re Air Crash Disaster at New Orleans, La.*, 795 F.2d 1230, 1233 (5th Cir. 1986)] Moreover, "[a]n expert witness must show special knowledge of the very question upon which he is to express an opinion." *George v. Morgan Constr. Co.*, 389 F. Supp. 253, 259 (E.D. Pa. 1975) (emphasis added); *see also* 2 John H. Wigmore, EVIDENCE IN TRIALS AT COMMON LAW § 555, at 750 (1979) (the qualification of a witness "is a fitness to answer on that point. He may be fit to answer about countless other matters, but that does not justify accepting his views on the matter in hand . . . .").

Here, Dr. Renfroe does not have sufficient expertise about Ford, its officials or employees, its design process, or its decision-making process, to express an expert opinion on Ford's internal standard for rollover resistance regarding the 1996 Ford Explorer. He may have read a number of Ford documents that he has acquired or that were provided to him by Plaintiff's counsel, but that activity is not sufficient to transform him into an expert. *See Hooten v. State*, 492 So. 2d 948, 957-58 (Miss. 1986) (although

witness "had read books on forensic document work, his practical training and experience in that field have not . . . 'clearly qualified him as an expert'"). If it were, any person could become an expert in any field merely by reading books or published articles in that field.

B. <u>**Testimony by Plaintiffs'/Intervenors' Experts about Ford's Knowledge or Intent Will Not Assist the Trier of Fact.**</u>

For expert testimony to be admissible, it must "actually assist the jury in arriving at an intelligent and sound verdict," *Viterbo*, 826 F.2d at 422, by "inform[ing] the court about affairs not within the full understanding of the average man." *United States v. Webb*, 625 F.2d 709 (5th Cir. 1980) (emphasis added). As one Texas court of appeals has stated, "the use of expert testimony is restricted to those situations in which the expert's knowledge and experience . . . are beyond that of the average juror . . . ." *Dunnington v. State*, 740 S.W.2d 896, 898 (Tex. App.--El Paso 1987, pet. ref'd); *see also Bristol-Myers Co. v. Gonzales*, 548 S.W.2d 416, 431 (Tex. Civ. App.--Corpus Christi 1976), rev'd on other grounds, 561 S.W.2d 801 (Tex. 1978) ("it was error for the trial court not to have excluded" testimony "where the tribunal is in possession of the same information as the witness").

Dr. Renfroe's knowledge and experience about Ford, its employees, and its decision-making process, are not "beyond that of the average juror." Numerous courts have held that testimony that addresses issues such as intent, character, and motivation of parties — are particularly "[w]ithin the ken of lay jurors," and thus expert testimony on such issues is inadmissible. *Webb*, 625 F.2d at 711 [quoting *United States v. Fosher*, 590 F.2d 381, 383 (1st Cir. 1979)]. In *Thomas v. State*, the court ruled that expert testimony about the reliability of eyewitness testimony was inadmissible because "any member of the jury could 'form an opinion on the issue equally readily and with the same degree of

logic as the witness.'" 748 S.W.2d 539, 541 (Tex. App.--Houston [1st Dist.] 1988, no pet.)

Because issues such as motivation, intent, and character are readily understood by the jury, expert testimony on such subjects would improperly impinge on the jury purpose:

> Procedures which curtail or impinge upon the jury's role are strictly drawn, strictly scrutinized and viewed with skepticism. This applies . . . to practices which tend to seduce the jury into abrogating its function and deferring its responsibility to other evaluators.
>
> * * * *
>
> . . . Expert testimony is not justified by the . . . need to preclude the jury from making up its own mind. It is justified when it enables the jury to heighten its appreciation of the full import of the evidence.

Dunnington, 740 S.W.2d at 898-99. Accordingly, such expert testimony does not assist the jury and must be excluded.

Furthermore, testimony will not assist the jury if it is based on unsupported assumptions and speculation. As the court stated in *Golleher v. Herrera*, "opinion evidence based on speculation or conjecture lacks probative value, and is inadmissible." 651 S.W.2d 329, 334 (Tex. App.--Amarillo 1983, no writ) (Citations omitted). These types of speculations are particularly troublesome because the testimony of an "expert" generally has an "aura of special reliability and trustworthiness." *United States v. Aramal*, 488 F.2d 1148, 1153 (9th Cir. 1973); *see also Christophersen v. Allied-Signal Corp.*, 939 F.2d 1106, 1112 n.10 (5th Cir. 1991), *cert. denied*, 112 S.Ct. 1280 (1992) ("expert testimony creates the risk of a special kind of prejudice"). The expert's pronouncements about the purported meaning of documents will inevitably color jurors' perceptions about the same documents. Thus, rather than examining the documents to see what they <u>in</u> <u>fact</u> say, jurors will instead be misled into reading "between the lines" of the documents and speculating about what the document "really" means. This does not

assist the jury; it "seduc[es] the jury into abrogating its function and deferring its responsibility to other evaluators." *Dunnington*, 740 S.W.2d at 898-99.

III. <u>TESTIMONY BY DR. RENFROE ABOUT FORD'S PURPORTED INTERNAL STANDARD FOR ROLLOVER RESISTANCE, BASED ON DOCUMENTS PRODUCED BY FORD, SHOULD BE EXCLUDED UNDER RULE 403 OF THE FEDERAL RULES OF EVIDENCE.</u>

In addition, such testimony will confuse the jury, unduly prolong the trial, and unfairly prejudice Ford. As noted by the *Daubert* Court:

> Expert evidence can be both powerful and quite misleading because of the difficulty in evaluating it. Because of this risk, the judge in weighing possible prejudice against probative force under Rule 403 of the present rules exercises more control over experts than over lay witnesses.

Daubert v. Merrill Dow Pharmaceuticals, Inc., 509 U.S. 579, 595, 113 S. Ct. 2786, 2798, 125 L. Ed. 2d 469, 484 (1993). Accordingly, the Court should exercise its sound discretion and exclude such testimony on the documents under Rule 403 of the Federal Rules of Evidence.

Such testimony will unduly and unnecessarily prolong the trial. To effectively cross-examine Dr. Renfroe on his opinions with respect to Ford's internal standard for rollover resistance, Ford will have to question the witness about his alleged interpretation of each document, and will have to ask the witness about other documents, not discussed by him, that rebut or refute his views. Ford will also have to call on rebuttal the authors of the documents so they can explain what they meant when they wrote the documents. As a result, the upcoming trial, which should focus on the accident at issue, will expand into a series of "minitrials" on the meaning of documents that for the most part are collateral to any disputed issue, hindering and confusing the jury's understanding of the essential issues in this case.

Furthermore, such evidence would be unfairly prejudicial if it has "an undue tendency to suggest decision on an improper basis, commonly, though not necessarily, an

emotional one." Advisory Committee note to Fed. R. Evid. 403. The Advisory Committee also recognized that evidence should be excluded if it

> "appeals to the jury's sympathies, arouses its sense of horror, provokes its instinct to punish, or triggers other mainsprings of human action [and] may cause a jury to base its decision on something other than the established propositions in the case."

Thronson v. Meisels, 800 F.2d 136, 142 (7th Cir. 1986) [quoting 1 J. Weinstein & M. Berger, WEINSTEIN'S EVIDENCE ¶ 403[03] (1985)].

IV. CONCLUSION

For the foregoing reasons, Dr. Renfroe's proposed testimony regarding Ford's internal standard for rollover resistance is inadmissible under *Daubert* and Rules 702 and 403. Dr. Renfroe's proposed testimony, therefore, must be excluded.

Respectfully submitted,

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(Admitted Pro Hac Vice)

ATTORNEYS FOR DEFENDANT
FORD MOTOR COMPANY

CERTIFICATE OF SERVICE

I hereby certify that a true and correct copy of the foregoing instrument has been forwarded to all known counsel of record as set forth below by certified mail, return receipt requested, in compliance with the Federal Rules of Civil Procedure on this 31st day of January, 2005.

Via Certified Mail

Brantley White
900 Frost Bank Plaza
802 N. Carancahua
Corpus Christi, TX 78470

Gerald F. Girodano, Jr.

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Renfroe engineering, inc.
conclusive analysis. compelling ideas.

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November 15, 2004

Brantley White
Sico White Braugh LLP
802 North Caranchua
Corpus Christi, Texas 78470

RE: *Irma Herriandez vs. Ford*

Dear Mr. White,

Enclosed is Investigative Report on the above case .

Should you have any questions regarding the above matter, please do not hesitate to contact us.

Sincerely,

Bonnie R. Wolf

Bonnie R. Wolf
Renfroe Engineering, Inc.

RECEIVED
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BY:

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conclusive analysis. compelling ideas.

INVESTIGATIVE REPORT

- ON BEHALF OF -

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IRMA HERNANDEZ

vs.

FORD MOTOR COMPANY

DAVID A. RENFROE, Ph.D., P.E.

NOVEMBER 4, 2004

Renfroe Engineering, Inc.
Post Office Box 610, Farmington, Arkansas 72730-0610
Tel: (479) 846-8000; Fax: (479) 846-8002; Email: info@renfroe.com

Hernandez, Irma
1377-003175

INVESTIGATIVE SUMMARY

Irma Hernandez was driving a 1996 Ford Explorer northbound on Hwy 6 in College Station, TX. The driver swerved to avoid a vehicle and was unable to maintain longitudinal control of her vehicle. The vehicle entered a final yaw and rolled on the roadway.

This accident and all related injuries were due to the design defects in the Ford Explorer. The design defects contributing to the accident is its poor rollover resistance.

QUESTIONS ASKED OF RENFROE ENGINEERING

- Is the design of the 1996 Ford Explorer defective in any way that contributed to this accident?

BACKGROUND INFORMATION

ACCIDENT DATE: January 25th, 2004
4:38 p.m.

LOCATION: 2300 Hwy 6 (Earl Rudder Freeway)
0.5 Miles S of Hwy 30 (Harvey Rd.)
College Station, Brazos Co., TX

VEHICLE 1: 1996 Ford Explorer 4Door 4x2

VIN:	1FMDU32X5TZA00556
Driver:	Irma Hernandez
R/F:	Ana Hernandez
R/L:	Ana Hernandez
R/M:	Anibal Hernandez
R/R:	Jose Hernandez

CONDITIONS: Daylight; Clear
Dry; Blacktop

EXPERT QUALIFICATIONS AND BASIS FOR OPINIONS

Dr. David Renfroe's qualifications as an expert in automobile vehicle dynamics, accident reconstruction, occupant motion kinematics, and other vehicle design related topics is a result of his education and experience. He received a Ph.D. in mechanical engineering in 1981 from Texas A&M University. Since 1977 he has been teaching the principles of dynamics and engineering which are applicable in the analysis of vehicle handling systems. Through the 1980's and 90's, he taught classes at the university level in vehicle dynamics and special project classes on vehicle design, construction, and testing. For over 20 years he has analyzed the dynamics of vehicles in accident situations for private consulting clients. In these projects, he has personally tested vehicles and measured the handling responses of these vehicles and analyzed the resulting data to determine the dynamic characteristics of these vehicles. Over the past 15 years he has designed, built, and tested high performance off road vehicles. This process has required an extensive knowledge of vehicle dynamics, application of these principles, and testing the resulting machine for compliance with the design objectives. As a result of this process, he has been awarded four patents and has published over 35 papers in refereed journals and publications pertaining generally to mechanical engineering, many of which are specific to vehicle design and dynamics.

MATERIALS REVIEWED

INFORMATION PROVIDED BY CLIENT FIRM

1. Traffic report
2. City of College Station Police Department release to media
3. City of College Station Police Department records
4. Letter to Detective Massey from Rachael Leach dated 02-26-04
5. City of College Station Police Department additional records
6. Copy of certified mail receipt to Irma Hernandez
7. Copy of signature receipt for certified mail
8. City of College Station Police Department evidence/ property release authorization
9. Copy of USPS receipt for sender: College Station Police Department
10. Photos of scene
11. Copy of the Accident Reconstruction report done by The Irwin Company
12. Deposition & Exhibit of James P. Hoemann
13. Deposition of Michael K. Swearingen
14. Deposition of Quinn D. Ellisdon
15. Deposition of Wendie Borskie Knight

SITE INSPECTION

Renfroe Engineering inspected the accident site on August 23, 2004. Highway 6 in the area of the accident has 2 northbound lanes that are separated from the southbound lanes by a large grass median. A paved shoulder and rumble strip separates the left northbound lane from the median. There is no major vertical pavement edge in the transition from median to roadway.

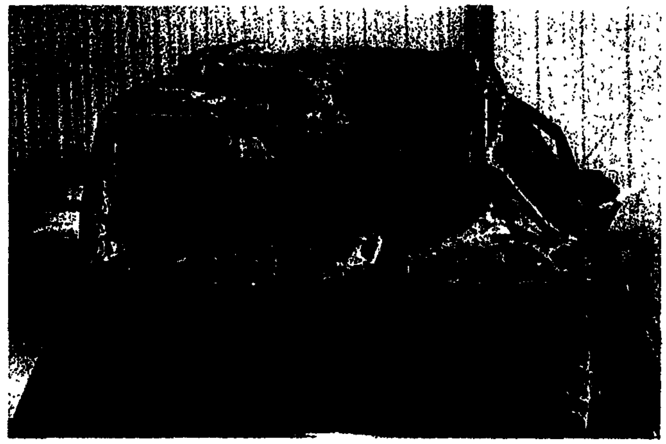
At the time of the inspection there are no visible tire marks. There are, however, several rim gouge marks, scrape marks, and various gouges, along what would have been the vehicles roll path.

All the remaining scene evidence, road edges, road lines, and median profile were measured and recorded.

VEHICLE INSPECTION

Renfroe Engineering inspected the case vehicle on August 24, 2004. The vehicle is a 4-door Ford Explorer, 2-wheel drive. The VIN number is 1FMDU32X5TZA00556. The date of manufacture is August of 1995. The recommended tire size is P235/75R15 with an inflation pressure of 26 psi on the front and back.

Inspecting the glazing on the vehicle, the windshield is broken out and collapsed onto the dashboard. The driver's front window is knocked out and was up at the time of the collision. There is glass at the top of the window frame. The driver's rear window was also knocked out and up at the time of the accident. All of the glazing in the cargo area including the rear window is knocked out. The right rear window is in place. The small pane of glass behind the movable section is knocked out. The right front window is broken out and was up at the time of the accident. There is glass in the top of that frame.



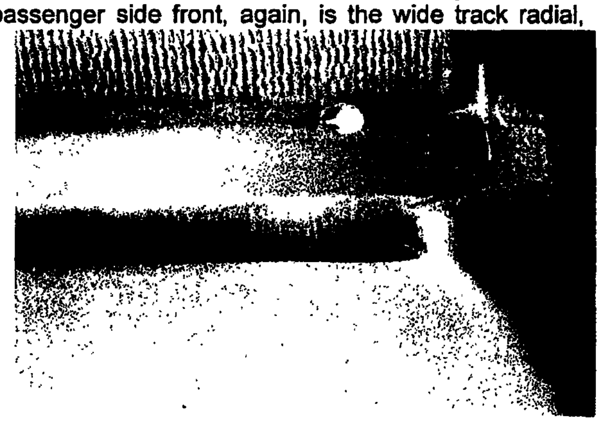
The driver's side front is a wide-track radial, possibly AT. The tire is folded under. The tire size is P235/75R15.

The driver's side rear tire is a Michelin LTX AT. Tire size again is 235/75 15. There are scrape marks on the rim around 50% of the perimeter

The passenger side rear tire is a Michelin LTX. The entire end of the axle is bent with the top being outward. The tire is actually broken off the end of the axle and is held on by the brake assembly. The tire is partially inflated. The passenger side front, again, is the wide track radial, possibly AS and is partially deflated. The rim has scratches on a 25% section of the outer perimeter.

The mileage on the vehicle reads 101098. The shift indicator is in Drive. The vehicle has metal RCF type buckles. The front appears to be webbing in a plastic stalk. The D-rings are metal.

Inspecting the driver's seat belt, there are loading marks on the slip-ring (shown to the right), and there is hair from the occupant on the rear upper portion of the doorframe or the window frame.



ACCIDENT RECONSTRUCTION

According to the "Accident Reconstruction Report" by Steve Irwin of The Irwin Company, "the vehicle rolled passenger side leading while it was on the pavement." The vehicle rolled 2 ½ times over about 134 ft. The speed at the point of roll is near 45 miles per hour.

AUTOMOTIVE STABILITY OVERVIEW

In this section of the report, the following questions will be answered:

1. What is Ford's internal standard for rollover resistance of a vehicle?
2. Does the Explorer pass Ford's internal standard?
3. What was Ford's knowledge concerning the rollover propensity of the Explorer and when did they know?
4. Was this particular Ford Explorer defective in any way that contributed to this accident?

WHAT IS FORD'S INTERNAL STANDARD FOR ROLLOVER RESISTANCE OF A VEHICLE?

In a Ford document dated November 18, 1986, titled *Light Truck Limit Handling Objectives*, Paul Hackett and K. P. Snodgrass stated, "...Trucks must still be designed to be safe and predictable in even the **most severe accident avoidance situations**. Light Truck Engineering's goal is to design a truck that will provide safe and predictable response in **limit handling situations**" (emphasis added) [108]. Hackett and Snodgrass further promoted this idea in a presentation, "The objective of this half of the presentation is to describe six important vehicle parameters that influence vehicle limit handling characteristics and their relationship to steering and suspension parameters. Limit handling refers to the behavior of a vehicle at the maximum lateral acceleration the vehicle is capable of reaching. A vehicle should be controllable, predictable and stable up to and including the limit of lateral acceleration" [56]. In a 1973 letter that Ford sent to the National Highway Traffic and Safety Administration, Ford stated on page 3, "Passenger cars must be forgiving of all manner of 'unskilled' driver situations that precipitate wild, panic-motivated, evasive maneuvers of drivers of widely-varying abilities. Ford passenger cars are designed to forgive or, in the extreme, to 'slide-out' rather than roll over" [109]. Again, the philosophy was restated with regard to the Bronco II in reference 127 page 2 wherein the authors in justifying the over-involvement of Jeep CJ's in rollover accidents state that the Bronco II the design process "Optimized vehicle handling parameters which virtually **preclude** vehicle over-reaction to excessive steering wheel inputs in accident avoidance maneuvers." On page 2 this was further expanded by saying, "the Bronco II is projected to **remain stable** for all speeds at the **maximum steering wheel input demand** as determined from human factors analysis." This design attitude was confirmed by Helen Petrauskas, Ford's VP of Environment and Safety Engineering, in her testimony before the Committee on Commerce, U.S. House of Representatives in September, 2000, when she referred to the previously cited guideline and said, "The objective of this guideline is to design and develop a vehicle that will remain stable under all operating conditions, including accident avoidance maneuvers. The guideline states that the vehicle should respond in a predictable manner and give the driver perceptible signals that the vehicle is at its limit" [110]. This is historically consistent with Ford's design philosophy dating from 1971, where C. R. Ennos, Manager of Body Research and Engineering at Ford, stated, "Primarily, the vehicle's handling characteristics should prevent rollover occurring unless excessively severe conditions are encountered. Our test technique should demonstrate, therefore, that vehicle's handling characteristics are anti-rollover" [32]. Thus this anti-rollover design philosophy has existed at Ford over the entire duration of the design and construction of the Ford Explorer from 1971 till September of 2000.

According to recent NHTSA findings, the most severe accident avoidance situation is the road edge recovery. This occurs when a driver drives two wheels off the paved portion of the road, and then attempts to reenter the paved road surface. "Due to the lip between the pavement and the shoulder, a substantial steer angle is required to start the vehicle moving to the left. However, once the vehicle overcomes the lip and starts moving, it quickly threatens to depart from the left side of the road. Therefore, the driver rapidly counter steers to the right. This pattern of steering during a road edge recovery was discovered during research done by the Texas Transportation Institute" [98]. The test, which most closely simulates that situation, is the roll rate feedback fishhook maneuver, which has been renamed the Road Edge Recovery Maneuver. Unlike the J-Turn that Ms. Petrauskas claims to be the most severe maneuver, NHTSA has found it "is not severe enough" for a stand-alone rollover resistance test to provide adequate information to the consumer on the rollover propensity of a vehicle. However, even using the less severe J-Turn test, Ford claims that a vehicle would not meet its design guidelines if it lifted two wheels simultaneously during the test. Although Ford ran actual tests on the Explorer in 1989 wherein they achieved two wheel lift on multiple J-Turn tests and CU short course tests [9], they elected to "sign-off" the vehicle design using an ADAMS computer model. There is no evidence of any validation runs of the ADAMS model and no data from any of the

runs currently exists. NHTSA says that a computer model is not an appropriate way of "testing" for rollover since there are so many non-linear tire and suspension characteristics that are not accounted for in the model [109]. Therefore, when Ms. Petrauskas says that Ford has "passed" these strenuous design goals with the Ford Explorer, there have actually been no J-Turn tests or steering reversal tests of any kind performed wherein the production Explorer did not lift two wheels.

Ford Motor Co. not only knew that the Ford Explorer was being *used* as a passenger car, but they also *marketed* the vehicle to be used as a passenger vehicle. The bottom line appears to be a consensus, especially at Ford, that the vehicle should not rollover on a flat and level surface from steering inputs alone.

Some defense experts allege that a vehicle's ability to roll over on a flat surface from steering inputs alone does not constitute a design defect. This allegation is based on testing that was done by the University of Michigan on a Dodge Coronet and an American Motors Corporation Ambassador in the early 1970s. Rollover occurred on the Coronet from a violent steering input combined with a hard brake application. The shock absorbers were significantly degraded and the front toe-in was drastically out of alignment. Another factor in the rollover was that the lateral force capability of the tires had been significantly increased due to the wear of the shoulder of the tread of the tire from repeated limit test maneuvers. They commented that this was a case where the experimentation affected the outcome of the experiment. Defendant experts draw the misleading conclusion that "Overturn of vehicles, including passenger cars [on flat and level pavement or a flat paved surface], is not evidence of a defective design." If the design of the tested vehicles were being tested in this study, that statement would be true. However, that testing was reported in the document titled, "Limit Handling Performance as Influenced by Degradation of Steering and Suspension Systems," published in 1972 [106]. Obviously these vehicles were being tested with worn out shocks, badly misaligned front wheels, and severely worn tires which developed as much as 40% more lateral force than would normally worn tires. These tests were not intended to evaluate the design of the vehicle but rather the effects of degraded suspension systems on vehicle handling. As designed, the vehicle was non-defective, but from this regimen of testing vehicle design problems cannot be criticized since the vehicle was not tested in the as-designed condition. One conclusion that can be reached, however, is that roll acceleration coupled with lateral acceleration does affect the roll propensity of a vehicle. This roll velocity and acceleration is heavily influenced by the shock absorbers on the vehicle. If they are worn and their damping effects are diminished, then roll velocities and accelerations will increase during steering reversals and/or steer plus braking, which will add to the propensity of a vehicle to roll over. These steering reversals can be linked in a series of steers to correspond to the natural frequency of the spring mass system about the roll axis. This will cause the amplitude of each roll of the sprung mass over the suspension to increase until sufficient momentum is developed to cause a normally non-defective vehicle to rollover. The statement that "any" vehicle can be rolled based on the University of Michigan study is clearly a false statement and is used out of context by some defense experts. My own testing shows that vehicles can be designed that will not roll on flat paved surfaces from steering inputs only, no matter how violent the steering inputs. These vehicles can still perform the off-road tasks of the sport utility class of vehicles. The Ford Explorer could have been designed to properly function as an SUV and also to adequately perform in off road situations without compromising the safety of the occupants.

Defense experts also allege that any vehicle can be rolled over with steering inputs that "exceeds the likely demands of drivers" or "exceeds the likely demands of normal driving" or "exceeds the reasonably anticipated crash avoidance demands." What defense experts would like to convince the jury is that there are "inappropriate" steering inputs that would never be used by drivers of these vehicles. The bounds of "likely" and "reasonable" are surmised from a study that was done in 1976 which is called the "Man-Off-the-Street" study [107]. One objective of this study was to determine how a driver responds to emergency situations. One result of the testing was that "the **average** of the maximum steering rates for **successful** runs was about 520 degrees per second." The authors go on to say that the average peak maneuvering severity of these maneuvers was about 0.46 g. Defense experts would infer that this was for a surprise emergency avoidance maneuver. However, in deposition testimony of Tandy [112], he stated that anyone who testified that the maximum lateral acceleration a person would subject themselves to was less than 0.5 g's based on the "Man-Off-The-street" paper would be misrepresenting the truth. However, in previous depositions, both Mr. Tandy and Mr. Carr have testified that it is not necessary to design a vehicle that can perform beyond what

the "average" driver who was able to "successfully" avoid collision with an object put into their path by surprise would require. They also have implied that it is humanly impossible or happens only by some freak of nature to steer the vehicle with steering rates higher than 520 degrees per second and thus, it is not reasonable to expect a manufacturer to design a vehicle that could withstand this type of treatment without a catastrophic conclusion. But in the same paragraph in the "Man-Off-The-Street" study [107], the reporters go on to say that eleven observations of runs involved loss of control and showed steering rates in excess of 1000 degrees per second. Thus, there are drivers who will steer a vehicle in excess of 1000 degrees per second, and in the process of losing control will be experiencing lateral accelerations in excess of 0.7 g's. Interestingly, *none of these vehicles rolled over.* They either spun out or slid out as they lost control. Obviously, it is the objective of Ford and other manufacturers from their own statements to design the vehicle such that all customers will be safe if they try to maneuver around a bouncing ball followed by a child [9]. They intended to do this by designing the vehicle such that it would not roll over on a flat surface with steering input only as evidenced by testing that was conducted by Ford [9].

What are some generally accepted tests or measures to determine the roll resistance of a vehicle?

There are static and dynamic measures that may be taken to establish the propensity of a vehicle to rollover in an accident evasive maneuver. The most effective is a dynamic test. However, a static measure of the vehicle can give an indication, all other things being equal, of the tendency of a vehicle to roll over compared to another vehicle. Static measures are the static stability factor (SSF), the Versace metric, tilt table test, and the lateral side pull test. The static stability factor is the simplest to use and has been shown to be statistically relevant to actual rollover frequency of vehicles [111]. It is merely a comparison of the track width to the center of gravity height. Statistics gathered and analyzed by NHTSA illustrate this relationship in Fig. 1 [105].

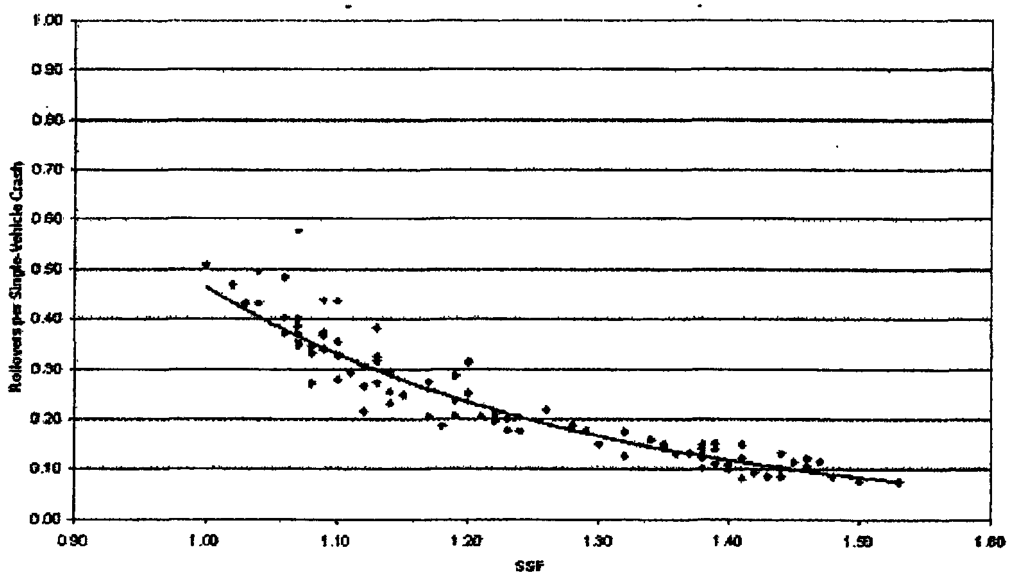


Figure 1: Rollovers per Single-Vehicle Crash Estimated from Six States (Averages Across States for Each Vehicle Group) [NHTSA].

Figure 1 is from a NHTSA rollover prevention docket and illustrates how a decrease in static stability factor (SSF) is associated with a higher number of rollovers. Note that as the SSF decreases, indicating a taller and narrower vehicle, the obvious result is for the number of rollovers to increase. NHTSA estimates that the number of rollovers per single-vehicle crash declines by half with a 0.21 increase in SSF.

Generally accepted and utilized dynamic tests for rollover resistance detection all consist of a maneuver which tests both the ability of the vehicle to withstand lateral accelerations up to the limit of adhesion of the tires, and the effect of the roll of the body during a steering reversal. A normal driver

will experience this condition when they attempt to avoid an accident by quickly steering around it and also remain on the road. Two frequently used tests are the Consumer's Union short course and the European "Moose" test. They are described in detail in Ref. 111.

The most frequently used and discussed test is the CU short course. Ford used it extensively during their development of the Bronco II and the Explorer. NHTSA says, "From a vehicle manufacturer's perspective, the double lane change maneuver is a good test to evaluate a vehicle's limit handling behavior, because it is a realistic maneuver and it allows engineers to simultaneously evaluate the three main behaviors that affect limit handling safety..." [105]. D.R. Wotton illustrated in a report that the CU course is *highly effective* in simulating the most likely customer usage in the operation of vehicle controls [62].

FORD'S P6-101 TESTING

Ford has a battery of tests for evaluating the vehicle handling that it labels P6-101 testing. This set of tests does evaluate the vehicle's handling but does not address the rollover stability of the vehicle. At no point is the vehicle's lateral roll characteristics exercised to its limit. The conditions of maximum rollover dynamics occurs when the maximum lateral acceleration that can be generated by the friction of the tires coincides with the maximum roll angle, roll velocity, and roll acceleration. These maxima can be experienced without rolling most vehicles over. If a test does not cause the vehicle to experience these conditions, then it is not an appropriate test for rollover resistance. None of the P6-101 tests generate these dynamics in a vehicle.

P6-101 tests were conducted on a 1996 Ford Explorer 4X2. Tests 1 – 47 were with the vehicle at curb weight. Thus none of the tests could have been for the maximum conditions that the vehicle would experience in its foreseeable life. Tests 48 – 84 were at GVW and thus the first criterion for maximum foreseeable severity was met. On none of the tests, 1 – 84 was there sufficient data taken to determine the level of severity of the maneuver in the rollover mode. Even if the data were measured, the reporting method is so inadequate that no meaningful calculations or conclusions can be drawn concerning the rollover performance of the vehicle. On the "maximum handling on handling course tests", the maximum lateral acceleration measured was only 0.75 g's. These are not maximum conditions. The single lane change maneuvers do not generate the steering reversals necessary to generate the conditions seen in real world accidence avoidance maneuvers where there is a double lane change, contrary to the testimony of Ms. Petrauskas before the US Congress in 2000 that the Ford tests push the vehicle to its most severe accident avoidance conditions. The double lane change tests being conducted in the P6-101 are adopted from the ISO standard, which do not reverse the steer immediately, but allow the vehicle roll velocity to stabilize before initiating the reverse steer. NHTSA has stated that this is not going to generate the maximum rollover dynamics in a vehicle and thus was not considered for its testing methodology as a part of its response to the Tread Act for NCAP rollover metrics.

DOES THE EXPLORER PASS FORD'S INTERNAL STANDARD?

First, we have discussed that Ford's design philosophy since 1971 has been to design vehicle's that do not roll over on a flat surface from steering inputs alone. Their sign-off procedure does not exercise the vehicle design sufficient to determine the rollover limits of a vehicle. First the J- turn is an inappropriate maneuver to excite the worst-case rollover scenarios. In reference 111 page 62540 NHTSA states, "The J-turn maneuver with a driver and instruments (light load configuration) is the least stringent. It would be rare for this maneuver to cause tip-up of a modern vehicle." Also, RF Stornant, of Ford engineering, questions the validity of using an ADAMS to model J-turns at the limit of the tires' capability. Because of its unreliability at the limit, it is an inappropriate choice of techniques for a rollover signoff procedure. However, with those limitations, does the Explorer even pass these weak standards?

No. Ford has not produced any evidence that they ever passed their own rollover criteria by producing the results of ADAMS modeling of their various vehicle configurations of doors, drives, and tires. No input or output data has been produced on any of the models from the UN46 or UN105 ADAMS to illustrate that the vehicle can pass even this rudimentary standard.

Testing conducted by Ford in 1989 and reported by R. Stornant to C. White indicated that the UN46 could not pass the CU short course test without rolling over [4]. The question arises if the UN46 as tested was equivalent to the production vehicle. Don Tandy confirms that the UN 46 is the production Explorer from 1991 through 1994. In my own testing, the Ford Explorer rolls over in a CU short course maneuver for the 1991–1994 vehicles just as it did in the Ford testing [9]. The 1995–2001 vehicles performed in an equivalent manner in my dynamic testing. Although there were design changes in 1995 and a "freshening" in 1998, the dynamic characteristics were not significantly altered over what was found from the testing of the UN46 until the 2002 model. Although ample opportunity existed, Ford refused to widen the track width of the vehicle until 2002.

A couple of examples illustrating the performance of a typically outfitted Ford Explorer are given here. Dynamic testing of a 1998 two-wheel drive four-door Explorer was conducted (VIN # 1FMZU32EXWUA09081). Testing was done on March 16, 2001. The vehicle was tested with Firestone Wilderness AT P235/75R15 tires inflated to 26 PSI. Track width on the front and rear with both sets of tires is 58.5 inches. When tested with the 15-inch tires, two passenger weight configurations are tested. First in addition to the driver and test equipment, 150 pounds was added to the right front position, and 70 pounds of rear cargo was added to the vehicle. Secondly, the vehicle was loaded with driver and test equipment plus 150 pounds in the right front seat and 150 pounds in rear right and rear left seating positions.

In this testing, the vehicle lifted the wheels and completely tipped on numerous test runs. Graphs showed that the cornering acceleration required to achieve wheel lift was on the order of 0.8 g.

Testing with 15-inch tires loaded with 1 passenger and rear cargo

For this test, the vehicle was fitted with 15-inch tires, given additional ballast in the right front seating position and cargo area, and run through the tests. Track width remained at 58.5 inches. Wheel lift occurred in J-turn tests at 50 MPH during 270 and 360-degree tests. In the CU short course testing, the vehicle lifted the wheels at 35, 40, and 45 MPH, and tipped onto its outriggers at 50 MPH. Tipping occurred during Fishhook testing (similar to the NHTSA Road Edge Recovery Maneuver) at 45 MPH.

Testing with 15-inch tires loaded with 3 passengers

The Firestone Wilderness AT P235/75 R15 tires remain on the Explorer. The loading configuration was changed to driver plus 150 pounds in the right front, right rear, and left rear seating positions plus the test equipment. Loaded in this manner, the vehicle lifted two wheels in the 270 degree J-turn at 40 MPH and tilted onto the outriggers in the 360-degree J-turn at 40 MPH. When tested on the CU Short course, the Explorer tilted onto the outriggers at 35 MPH and again lifted wheels during the test at 40 MPH. The Explorer was also found to tilt onto the outriggers during the Fish Hook test at 35 MPH.

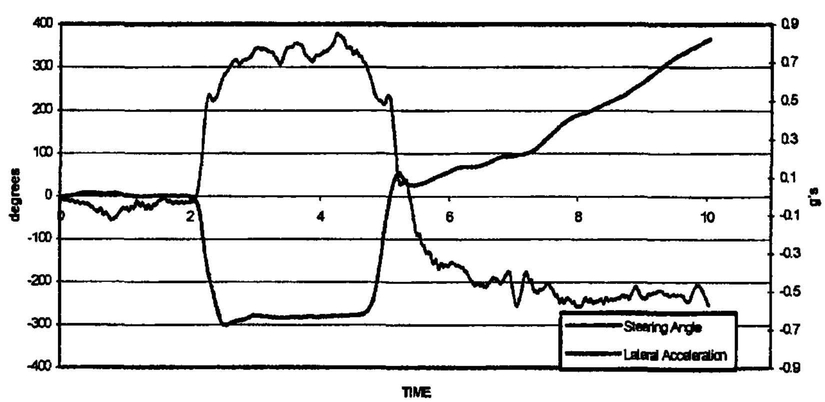


Figure 2: 1998 Explorer 4X2 Four Door, P235/75R15, Loaded with driver, test equipment, 1 passenger, and cargo, 270 Degree J-Turn 50 MPH, Test XRR19.

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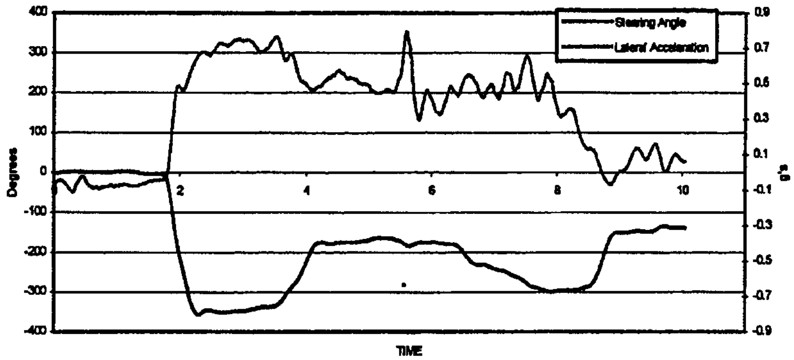

Figure 3: 1998 Explorer 4X2 Four Door, P235/75R15, Loaded with driver, test equipment, 3 150 lb occupants, 360 Degree J-Turn, 40 MPH, Test XRR28.

From the testing of the 1998 4-door Explorer 4X2 with Firestone Wilderness AT tires, it was found that the Explorer did not comply with the standard that Ford itself had suggested in any of the tests. The vehicle lifted wheels during a single steering maneuver as a result of steering input alone, and began to roll over if a dynamic transitional maneuver such as an accident avoidance maneuver were attempted. Therefore, the Ford Explorer cannot pass any of the tests suggested by NHTSA or used by Ford as a test for compliance of a rollover standard. Other tests using different loading configurations and tire fitments illustrate the same thing.

How can the vehicle be driven by defendant experts and show high lateral accelerations and compliance with certain tests?

The tests conducted by defense experts result in technical data and graphs that are extremely voluminous and colorful, but never illustrate how the vehicle performs at its limit. Tests such as the J266 circle test and the J-turn test are all uniform direction lateral acceleration tests. These are useful to determine handling characteristics but should never precipitate in rollover (although they do in some Explorer test configurations conducted both by Ford and myself). However, the defense experts never have demonstrated a rollover in such a maneuver (even though Ford does roll the vehicle in its tests) because they are careful not to exceed the rollover limit.

The most significant tests are lane change maneuvers where there is a change in the direction of the lateral forces causing a roll from one side to the other of the vehicle. This is the most dangerous of maneuvers, and is also most likely to be performed by a real world driver. This test simulates the condition where the driver will be attempting to avoid a collision and still remain on the road. When performing this maneuver to the limit of tire adhesion the vehicle should slide or spin out at the limit of performance and not roll [32,56,57,109,110]. The CU Short Course, as used by Ford in its testing, and the fish hook test, as performed by Toyota, are more severe than the ISO lane change test, as performed by defense experts. NHTSA states their findings show that the ISO lane change is actually two single lane changes and does not test for the effect of the roll momentum on the roll propensity of the vehicle [113]. Double lane change maneuvers such as the CU short course and the ISO 3888 part 2 would have no value as dynamic tests for rollover resistance, if the scoring basis were on the highest "clean" run [113]. The CU test, when performed as Ford and I did, resembled the results of the fishhook test. The fishhook and CU test begin with a steer to the left followed immediately by a steer to the right. The fish hook test holds the final right steer while the CU test adds a steering input back to the left to attempt to reenter the original lane of travel. The immediate steering reversal in both tests causes a high roll acceleration coincident with high lateral acceleration. The ISO lane change, however, steers to the left to a displaced lane, follows that lane for a distance, and then steers to the right to re-enter the original lane. This maneuver allows the roll velocity to stabilize before performing the right steer maneuver. This reduces the roll acceleration experienced by the vehicle and thereby does not test the vehicle at its limit.

When the maximum roll acceleration occurs at the same time as the maximum lateral acceleration, the most severe condition for the vehicle is experienced. The ISO maneuver does not allow for these two conditions to be maximized at the same time, whereas the CU and fishhook have the highest likelihood of those two accelerations coinciding. In performing the CU short course maneuver with the UN46, which later became the 1991–1994 Explorer, Ford did experience two wheel tip ups or rollovers. However, in later year models, Ford opted not to perform actual dynamic testing but instead only modeled the vehicle using ADAMS. Figliomeni stated in his deposition that the ADAMS models were never validated against actual testing. He was not aware that any physical testing had been performed. Although Ford has claimed that confirmatory testing has been performed, they have not maintained records of actual testing since 1989 when the vehicle failed in dynamic testing.

How can the vehicle be changed to be able to comply with these rollover standards?

A simple method of making any vehicle more stable is to make it wider and lower its center of gravity. As previously mentioned, the static stability ratio (or static stability factor, SSF) is a simple calculation relating track width (Tw) to the center of gravity height (H) for a given vehicle. The calculation is widely used as an indicator to evaluate the rollover propensity of vehicles. According to NHTSA, the SSF for 1995-1997 Explorers is 1.06 and for the 91-94 Explorers is approximately 1.07.

The industry seems to accept and agree that a static stability ratio above 1.2 is desirable. Whether agreed upon or not, it is well documented that when the stability ratio falls below 1.2, the risk of rollover increases significantly. The Bronco II, which also exhibits a high rollover propensity, has a SSF of 1.02. Jeeps also demonstrated a low SSF, 1.075 for the CJ-7 and 1.056 for the CJ-5. However, in 1986 Jeep redesigned the CJ in order to reduce its rollover propensity and reintroduced it as the Jeep Wrangler. Current production Jeep Wranglers have a static stability ratio of 1.2 and consequently rollover incidents for this model have been significantly reduced.

What is the performance of Vehicles with an increased SSF?

Testing was conducted to determine what the effect of increasing the track width and lowering the center of gravity would be on an Explorer's performance in the CU short course. Tests of other vehicles are also shown where an SUV does not rollover in severe steering reversal maneuvers. Important factors to consider in the tests include vehicle configuration and loading. If the tires are increased in size or the loading of the vehicle is increased, the rollover stability of the vehicle will be negatively affected.

1996 Ford Explorer:

Testing was been conducted on a 1996 Ford Explorer (VIN #1SMDU34X1TZA78961). The vehicle was equipped with Goodyear Wrangler RT/S tires size 235/75R15. With the standard tires the front track was 58-1/2 inches, and the rear track was 58-1/2 inches. The rear axle height was 13-3/8 inches and the front axle height was 13-3/4 inches.

Several tilt table tests were performed on the subject vehicle. The first test was with the suspension unlocked and the spare tire in place. With a platform angle of 45 degrees, the roll angle of the vehicle was 47.4 degrees. When the tire and suspension deflection are accounted for, the tilt table test illustrates that the lateral acceleration required to roll the vehicle will be approximately 0.935 g's. During the actual testing of the unmodified vehicle, the 50 MPH emergency avoidance maneuver produced a lateral acceleration of approximately 0.9 g's at 2.5 seconds, which precipitated a wheel lift transitioning into a rollover. This supports the results found in the tilt table test and shows that lateral accelerations of such magnitudes can be produced from the interaction of the tires on flat pavement.

The standard tires and wheels were replaced with reverse-out wheels, increasing the track width by 4 inches and using the smaller diameter Bridgestone tires, P225/70R15. The tires lowered the CG by 1-1/4 inches. The point at which the vehicle balanced on the tilt table test was measured at 51.2 degrees. The platform angle at the balanced point was 46.9 or 47 degrees. Thus by increasing the track width by approximately 4 inches and lowering the center of gravity by about 1-1/4 inches, the tilt table test results increased by 2 degrees. The lateral acceleration required to lift the inside wheels was determined in the tilt table test to be 1.068 g's.

During a 65-MPH CU short course test, lateral acceleration levels of around 0.9 g's were generated at the 2.5-second time with no wheel lift. The steering was reversed causing a dynamic shift in the weight of the vehicle and produced a lateral acceleration spike of over 1.1 g's at about 5.1 seconds, but no wheel lift was observed and no rollover occurred.

From the testing, it appeared that the lateral adhesion capability of the tires on the modified vehicle was exceeded before the rollover threshold of the vehicle. This is the desired performance at the limit of the vehicle's capabilities, rather than rollover. Therefore it is concluded that a small modification can make the vehicle incapable of rollover on a flat and level paved surface regardless of the speed.

2002 Ford Explorer:

Additionally, a 2002 model Ford Explorer XLT four-wheel drive four door (VIN 1FMDU73E52ZA12838) with the heavy-duty suspension was tested. The vehicle was tested with 16-inch tires with the front tires inflated to 30 PSI and the rear tires inflated to 35 PSI. The front track was measured at 61-1/8 inches and the rear track was measured to be 61-5/8 inches. No added ballasts were placed in the vehicle other than the driver and test instruments.

Tests were conducted on the same test course as all other vehicle testing. The vehicle was run through the CU Short Course test at 35 and 47 MPH, the J-Turn test at 45 MPH and the Fish Hook test at 40 and 50 MPH.

During testing, a maximum lateral acceleration of 0.93 g was reached with no tire lift. The vehicle performed well in the CU Short Course tests spinning out on the 47 MPH test with no wheel lift. The vehicle negotiated the Fish Hook and J-Turn tests exhibiting no over steer and no wheel lift. All vehicle testing indicated that the cornering capabilities of the tires were exceeded prior to sufficient lateral acceleration to roll the vehicle over. The result of this condition was that the vehicle slid along the road surface when subjected to these extreme maneuvers. This is the desired handling characteristic of any on road vehicle.

1985 Jeep Cherokee 4X4

A 1985 Jeep Cherokee 4 door, 4 wheel drive, equipped with Goodyear Wrangler P205/75R15 tires at 30 PSI, automatic transmission, and a 2.5 liter 4 cylinder engine. The vehicle was ballasted with 140 pounds in the right front, right rear, and left rear positions, and a 200-pound driver. There were numerous J turn and emergency avoidance maneuvers performed by Eliseco Systems with no tip-up on any of the tests.

1984 Chevrolet S-10 Blazer

A 1984 S-10 Chevrolet Blazer equipped with P205/75R15 tires at 35 PSI, was also tested through numerous J-Turn and emergency avoidance maneuver by Eliseco Systems with no tip-ups.

WHAT WAS FORD'S KNOWLEDGE CONCERNING THE ROLLOVER PROPENSITY OF THE EXPLORER AND WHEN DID THEY KNOW?

It is evident that Ford knew of the propensity of the Ford Explorer to roll over from testing conducted in 1989 and through testing conducted in 1995 on the UN 105. There is frequent interaction between Ford engineers and executives concerning the results of the testing demonstrating its propensity to roll and proposed solutions to the problem. They were aware of the rollover problems of the Jeep CJ-5 and CJ-7 in the '70's and 80's, which were alleviated by the introduction of the wider and lower Jeep Wrangler. Ford had also experienced similar situations concerning rollover incidents dating back to the Bronco II. It becomes rather obvious that Ford was aware of the rollover issues concerning the Ford Explorer. Not only did Ford's own testing show that there were rollover problems, but the high number of real world incidents certainly made Ford aware that attention should be directed toward this issue as evidenced by their own internal documents.

First of all, Ford was knowledgeable of the principles of rollover stability and how to design a vehicle such that it will not rollover on a flat and level surface as illustrated in their book of knowledge in LT Frame and Fuel manual [1]. They say that they can design a vehicle to "withstand high velocity sideslip and yaw rates without tripping."

On May 10, 1989 D.S. Starr reported to J. Avouris and R. Campbell that they had experienced two-wheel lift in a J-turn test with various tire and suspension configurations with the UN 46 [3]. According to Ford, two-wheel lift in a J-Turn constitutes a failure of their standard of performance. On May 16, 1989 Roger Stornant, wrote a memo to C. White stating that the UN 46 with a short wheelbase rolled in a J-turn test using P 245 tires [4]. In May 1989 a preliminary summary of test findings at the Arizona Proving Grounds [32] showed that there was two-wheel lift on the UN 46 under the conditions shown in Table 1:

Table I: Arizona Proving Ground Testing Summary.

Type	Tire	CU Long Speed (mph)	CU Short Speed (mph)	Tire Pressure (psi)
4 Door	245/75R 15 A/S	45	38	26
	245/70R 15 A/S	41	38	35
	235/75R 15 A/S	45	41	26
	235/75R 15 ATX	45	41	26
	225/70R 15 A/S	45	45	30/35
2 Door	235/75R 15 A/S		45	26
	235/75R 15 ATX		41	26

R. Stornant reported to C. White of an unsuccessful attempt to alleviate the rollover problem by increasing the stabilizer bar stiffness using P235/75R 15A/S tires on 6" wide rims [8]. A proposal was made to lower the frame by ½ inch, widen the track by 2 inches, lower the front roll center by 2 inches, and increase the roll stiffness [6]. This would have caused a one-year delay in the start of production. On June 26, 1989, C. White suggested to R. Stornant that they could make the production date if they start production with only the more stable four-door model using the P225/70R 15 A/S tires and a chassis lowered by ½ inch. He suggested that they could incorporate the other changes from 1991 to 1991 ½ release time [7]. Meanwhile, Mr. Figliomeni at Firestone, unaware that Ford had conducted actual tests of the UN 46, was modeling the vehicle with Adams using data obtained from Ford. He concludes that the 4 x 2 model was the least stable of the group. He also suggested that the ride height geometry be lowered ½ inch in the front and 1 inch in the rear [17], which would in turn lower the center of gravity.

What does testing on the Ford Explorer show?

In order to determine the rollover propensity of the Ford Explorer, numerous Explorers from 1991 through 2002 have been tested. Models tested include 2-door, 4-door, 4X2, 4X4, loaded and unloaded.

Testing on the 1999 Ford Explorer 4-door 2-wheel drive showed it to be unstable. The vehicle rolled over in a Consumer's Union short course maneuver at 45 MPH while on a flat and level surface. Although these tests were performed under loaded conditions with a driver and four passengers, the results are consistent with test results from other Ford Explorer testing from year models 1991-1999. These tests indicate that the vehicle is defective and inherently unsafe due to its rollover propensity.

Testing on the CU short course with 1998 Explorers has shown that rollover occurs at speeds as low as 35 mph for the 4 door, 2- wheel drive models. Although the rollover at 35 mph was under a loaded condition, rollover during testing occurred at 40 mph when loaded only with a driver.

A 1995 4-wheel drive model also tilted (or rolled over) at 40 mph in the CU course and the avoidance maneuver test.

A 1998 2-door, 4-wheel drive Explorer was tested. Tests showed that the vehicle experienced wheel lift at 40 mph and rolled over at 45 mph. When a 1999 2-door, 2-wheel drive model was tested in the same course, wheel lift occurred at 35 mph and rollover occurred at 40 mph.

Testing has shown over and over that Ford Explorers will rollover on flat level paved surfaces. When reviewing test results it becomes evident that the 2-wheel drive models don't perform any better than do the 4-wheel drive models. There are also indications that the 2 door models don't perform as well. As mentioned earlier, Figliomeni found that the 2-wheel drive Explorers is the least stable of the bunch. He also stated that the 2 door versions of the Explorer performed worse than do the 4-door versions [124].

WAS THIS PARTICULAR FORD EXPLORER DEFECTIVE IN ANY WAY THAT CONTRIBUTED TO THIS ACCIDENT?

Yes. A 1996 Ford Explorer 4dr 4x2 outfitted with P235/75 R15 tires rolled over in three different maneuvers. During a road edge recovery maneuver the vehicle lifted 2 wheels at 45 mph and rolled onto its outriggers at 50 mph. The vehicle also rolled over in the CU long course and a fishhook maneuver both at 40 mph.

Another 1996 Explorer 4dr 4x2 also with P235/75 R15 tires also rolled over in three different maneuvers. The vehicle rolled over in 2 different J-turn tests at 35 and 40 mph. It rolled over in a fishhook maneuver at 35 mph. It exhibited 2-wheel lift in the CU short course at 35 and 40 mph. It also rolled over in the CU short course at 45 mph.

RESULTS AND CONCLUSIONS

The Ford Explorer has a low static stability coefficient, which contributes to the vehicle rolling over on a flat and level surface. The track width of the vehicle is too narrow for the center of gravity height, which translates into a low T/2H ratio, or static stability factor. The SSF is well recognized as an indicator of a vehicle's roll propensity. With the loss of control, the vehicle should have slid sideways or spun out instead of rolling over on the road.

Testing of Ford Explorers has shown that a rollover will occur during accident avoidance maneuvers and fishhook tests. Ford knew of this dangerous condition in 1989 and did not correct the defects of the vehicle. The design defect in the SSF is easily corrected. This defect was corrected by increasing the track width and lowering the center of gravity as was illustrated in testing. Testing of the modified vehicle illustrated that its failure mode at the limit was to slide out and not rollover. Ford could have designed the Explorer with a higher SSF and decreased the risk of rollover while maintaining the explorer's usefulness as an SUV.

The 1996 Explorer rolled on level pavement as a result of the design defects of the vehicle. There appeared to be nothing on the roadway that would cause the trip of this vehicle. The design flaw causing a rollover on a flat and level surface is a high center of gravity coupled with a narrow track width along with poor stability characteristics. Had the vehicle had a wider track width, a lower center of gravity, and adequate handling characteristics it would not have rolled over and caused the injuries to Irma Hernandez. Whereas with the 1996 Ford Explorer, the loss of control caused the vehicle to transverse into a yaw and with the high center of gravity and high rollover propensity of the Ford Explorer, this resulted in on-road, un-tripped rollover.

It can be concluded that this rollover was a result of the poor stability characteristics associated with the Ford Explorer. It can be concluded that the defective design of the 1996 Ford Explorer is responsible for the injuries to Irma Hernandez who was belted at the time of the accident as documented in the police report and evident by loading marks on the slip ring.

Our conclusions are based on the information made available to us at the time of our investigation. Should any additional information be uncovered or made available, we retain the right to revise or supplement our report accordingly.

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